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NATIONAL DAM SAFETY PROGRAM, LAGUNA PALMA DAM (MO 30404), MISSI--ETC(U)
AUG 79 R J KIMBALL, J T HOCKENSMITH DACW43-79-C-0034

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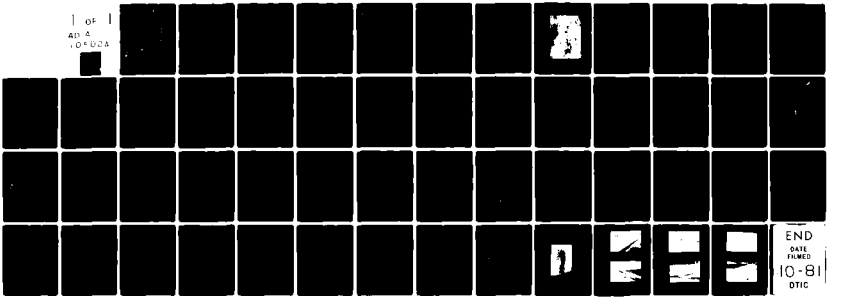

LEVEL II

MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

AD A105024

LAGUNA PALMA DAM

JEFFERSON COUNTY, MISSOURI

MO 30404

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
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St. Louis District

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PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

AUGUST 1979

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7. AUTHOR(s) L. Robert Kimball and Associates	8. CONTRACT OR GRANT NUMBER(s) DACW43-79-C-0034
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

LMSED-FI

SUBJECT: Laguna Palma Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Laguna Palma Dam.

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, emergency by the St. Louis District as a result of the application of the following criteria:

1. Spillway will not pass a 10-year frequency flood without overtopping of the dam. The spillway is, therefore, considered to be unusually small and seriously inadequate.

2. Overtopping could result in dam failure.

3. Dam failure significantly increases the hazard to life and property downstream.

SUBMITTED BY: SIGNED
Chief, Engineering Division — 26 FEB 1980 — Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer — 26 FEB 1980 — Date

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

NAME OF DAM	Laguna Palma
STATE LOCATED	Missouri
COUNTY LOCATED	Jefferson
STREAM	West Fork of Plattin Creek
DATE OF INSPECTION	May 2, 1979

Laguna Palma Dam was inspected using the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines are considered to represent a consensus of the engineering profession.

Based on the criteria in the guidelines, the dam is in the high hazard potential classification, which means that loss of life and appreciable property loss could occur in the event of failure of the dam. The dam is in the small size classification since it is greater than 25 feet high, but less than 40 feet high. Within the estimated damage zone approximately three miles downstream of the dam are nine dwellings, county roads and Highway T.

Based on the downstream affected area the Spillway Design Flood for this dam is the PMF (probable maximum flood). The spillway is capable of controlling approximately 3% of the PMF without overtopping the embankment. In addition, the spillway cannot control the 10 year storm.

Deficiencies visually observed for Laguna Palma Dam were no riprap on the upstream slope, cracking of the concrete gravity section and possible inoperable drain line valve. There is no warning system in effect or a safety inspection program. Stability, stress and seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspections of Dams" are not available which is considered a deficiency. These deficiencies should be remedied at the direction of a professional engineer knowledgeable in the design and construction of concrete and earth fill dams.

The owner should take action to correct or control these deficiencies.

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L. Robert Kimball & Associates
Vice President, Earth Sciences

JAMES T. HOCKENSMITH
L. Robert Kimball & Associates
Geologist

KUANG HWEI CHUANG, P.E.
L. Robert Kimball & Associates
Hydraulic Engineer

Laguna Palma Dam - Overview

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
LAGUNA PALMA DAM - ID NO. 30404

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, District Engineer directed that a safety inspection of the Laguna Palma Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspections of Dams". These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) Laguna Palma Dam is an earthfill dam with a concrete gravity spillway section. The concrete gravity section is approximately 90 feet long and 26 feet high. The earth portion of the dam is approximately 440 feet long and 15 feet high. A earth embankment has a bend in the upstream direction. The concrete core wall is located in the earth embankment section between the concrete gravity section and the bend in the earth embankment. The upstream slope does not contain any riprap. The slope varies from 1.5H:1V to 2.5H:1V. The downstream slope is variable and averages 3H:1V. The downstream slope is grassed.

The spillway is located in the concrete gravity section. The spillway is trapezoidal in shape with a bottom width of 60 feet. In the concrete gravity section six feet below the crest is a 24" cast iron pipe. This pipe is used as a drainline.

Upstream of Laguna Palma Dam is Lake Lacawanna which is an earthfill dam approximately 40 feet high. The spillway is a trapezoidal shaped earth cut with a bottom width of 12 feet.

b. Location. Laguna Palma Dam is located approximately 4.5 miles east of Vales Mines, Missouri on the West Fork of Plattin Creek. The dam can be located (Section 36, Township 39 North, Range 5 East) on the Halifax, Missouri 7.5 minute U.S.G.S quadrangle.

c. Size Classification. Laguna Palma Dam is a small size structure (26 feet high, 166 acre-feet).

d. Hazard Classification. Laguna Palma Dam is a high hazard dam. Downstream conditions indicate that loss of life is probable should failure of the dam occur. Within the estimated damage zone approximately three miles downstream of the dam are nine dwellings, county roads and Highway T.

e. Ownership. Laguna Palma Dam is owned by Harold Whitman. Correspondence should be addressed to:

Mr. Harold Whitman
Route 1
Desoto, Missouri 63020
314-937-8377

f. Purpose of Dam. Laguna Palma Dam is used for recreation.

g. Design and Construction History. Based on interviews with the owner Laguna Palma Dam was reportedly built in the early 1940's. The present owner bought the dam in 1970. No design drawings, reports or construction history exist.

h. Normal Operating Procedures. No operating records exist. The drainline has not been operated by the present owner. Excess inflow discharges over the spillway crest.

1.3 PERTINENT DATA

a. Drainage Area.

Laguna Palma Dam	7.07 square miles (U.S.G.S. quadrangle)
Lake Lackawanna Dam	2.30 square miles (U.S.G.S. quadrangle)

b. Discharge at Damsite (cfs).

(1) Maximum known flood at dam site	Unknown
(2) Spillway capacity at top of dam	1413
(3) Drainlines	Unknown

c. Elevation (feet) - Field survey based on spillway elevation 585 shown on U.S.G.S. quadrangle.

(1)	Top of dam	588.7
(2)	Spillway crest	585.0
(3)	Normal pool	585.0
(4)	Maximum pool (PMF)	597.8
(5)	Invert on 24" CIP	579.0
(6)	Tailwater on day of inspection	569.0
(7)	Streambed at centerline of dam	563.0

d. Reservoir (feet).

(1)	Length of maximum pool (top of dam)	3000
(2)	Length of normal pool	2200

e. Storage (acre-feet).

(1)	Top of dam	166
(2)	Spillway crest	98
(3)	Normal pool	98
(4)	Maximum pool (PMF)	422

f. Reservoir Surface (acres).

(1)	Top of dam	26
(2)	Spillway crest	16
(3)	Normal pool	16
(4)	Maximum pool (PMF)	36

g. Dam.

(1)	Type	Earth embankment with concrete gravity spillway
(2)	Length	530 feet
(3)	Height	26 feet
(4)	Top width - earth embankment	6 feet
	- concrete gravity section	2.5 feet
(5)	Side slopes	
	Earth embankment - upstream	Varies from 1.5H:1V to 2.5H:1V
	- downstream	3H:1V
	Concrete gravity section - upstream	Unknown
	- downstream	1H:5V
(6)	Zoning	None
(7)	Grout curtain	None

h. Spillway.

(1)	Type	Concrete gravity-trapezoidal shape
(2)	Length	60 feet
(3)	Crest elevation	585
(4)	Upstream channel	Lake
(5)	Downstream channel	West Fork
(6)	Weir shape	Trapezoidal

i. Drawdown Facilities.

(1)	Type	24" CIP
(2)	Elevation	579.0
(3)	Length	3.5 feet
(4)	Closure	Unknown

SECTION 2 - ENGINEERING DATA

2.1 DESIGN. No design drawings, reports or data are known to exist.

2.2 CONSTRUCTION. Based on interviews with the owner it is reported that the dam was constructed in the early 1940's. No information exists on the construction the dam.

2.3 OPERATION. No operating records exist.

2.4 EVALUATION.

a. Availability. There are no engineering data available.

b. Adequacy. The field surveys and visual inspections presented herein are considered adequate to support the conclusion of this report. Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be rectified.

c. Validity. Not applicable.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. The onsite inspection of Laguna Palma Dam was conducted by personnel of L. Robert Kimball and Associates on May 2, 1979. The inspection team consisted of a hydrologist, structural/soils engineer and a geologist. The inspection consisted of:

1. Visual inspection of the retaining structure, abutments, and toe.
2. Examaination of the spillway facilities, exposed portions of any outlet works, and other appurtenant works.
3. Observations affecting the runoff potential of the drainage basin.

b. Project Geology. The bedrock underlying Laguna Palma Lake consists primarily of the Roubidoux formation which is part of the Canadian Series of the Ordovician System. The Gasconade formation underlies the Roubidoux formation and is also exposed under part of the lake and probably the dam as well.

The Roubidoux formation contains sandstone, dolomitic sandstone and cherty dolomite. Except in the central part of the state, the sandstone accounts for little more than 10% of the formation, the remainder consisting mostly of cherty dolomite. The dolomite is light gray to brown, finely crystalline, and thinly to thickly bedded. The Roubidoux formation ranges in thickness from 100 to 250 feet, but is probably thinner here, since much of it has been eroded away.

The Gasconade is primarly a light brownish-gray cherty dolomite in this area. The lower part of the dolomite is coarsely crystalline and chert often makes up more than 50% of the volume of the rock. The upper part of the dolomite, which is present around Laguna Palma, is finely crystalling and contains much smaller amounts of chert. The chert may be white and porcelain-like or with brown and gray bands. Many of the nearly vertical cliffs in the central Ozarks are formed by the Gasconade. Springs and caves are also common in this formation, which may be from 300 to 700 feet thick.

Only one rock outcrop was observed during the inspection. This was at the right abutment of the dam and consisted of cherty dolomite. This may be either the Upper Gasconade or the lower Roubidoux. The rock was slightly weathered and exhibited some jointing while the beds were of moderate thickness. Solution cavities are ofter found in these rock types, but no evidence of karst terrain was observed in the vicinity. It is difficult

to distinguish any more detailed information on the basis of one brief inspection with only one outcrop. The published literature contains little else of value concerning these to formations.

Structural features in the vicinity of Laguna Palma include the Plattin Creek anticline, the axis of which passes the lake immediately to the west in a northeast-southwest direction. The axis plunges gently northwards. The eastern limb is slightly steeper, but both limbs are reported as gentle (no dips are given). The Rugley School fault block and fault are another structural feature lying two to three miles south of the lake. A component of the Valles Mines - Vineland fault zone which is, in turn, a part of the Ste. Genevieve fault system, the Rugley school fault is the largest of a series of faults bounding the Rugley school fault block. This is an untilted wedge of sediment marked by faults on the northwest, north and northeast. To the south, however, it merges with the Farmington anticline. The Rugley shcool fault brings the Davis Shale into contact with Gasconade Dolomite while the other faults have small displacements of only about 75 feet. Some seismic activity is still noted in this part of the state.

c. Dam and Spillway. Visual inspection of the dam indicated the structure was in fair condition. From a brief survey conducted during the inspection, it was determined that a low point on the dam is at elevation 588.7 adjacent to the concrete gravity spillway. The earth embankment section of the dam generally rises from the spillway section toward the left abutment. The earth embankment section is 440 feet long with a maximum height of approximately 15 feet. The upstream slope varies from 1.5H:1V to 2.5H:1V. The upstream slope of the dam is used as a boat dock. Small row boats and fishing craft are docked and pulled up on the upstream slope of the dam. The crest width is a maximum of approximately 6 feet wide. The downstream slope is variable and averages approximately 3H:1V. The downstream slope is grassed. No seepage or erosion was noted on the downstream slope at the time of inspection.

The right abutment section of the dam is formed by a concrete gravity section. This section is approximately 90 feet long of which 60 feet acts as a spillway. The concrete wall extends to the left of the spillway and forms part of the upstream slope of the earth embankment for about 50 feet. The spillway is trapezoidal in shape. The concrete in this section was in fair to poor condition. The concrete is deteriorating and several long diagonal cracks were noted on the downstream face. These diagonal cracks ran from near the spillway crest elevation to the tailwater. Condition of the upstream portion of the concrete and earth section were not visible because of the lake level. The downstream portion of the concrete gravity section below the tailwater was unobserved.

The right abutment section of the dam is formed by a concrete gravity section. This section is approximately 90 feet long of which 60 feet acts as a spillway. The spillway is trapezoidal in shape. The concrete in this section was in fair to poor condition. The concrete is deteriorating and several long diagonal cracks were noted on the downstream face. These diagonal cracks ran from near the spillway crest elevation to the tailwater. Condition of the upstream portion of the concrete and earth section were not visible because of the lake level. The downstream portion of the concrete gravity section below the tailwater was unobserved.

d. Drainlines. Approximately 6 feet below the spillway crest in the concrete gravity section is a 24" cast iron pipe. No controls were noted on the exposed downstream portion of this 24" cast iron pipe.

e. Reservoir Area. No pertinent problems were noted in the reservoir area. The watershed is moderately steep and wooded. Approximately 2 miles upstream of Laguna Palma Dam is an earth dam (Lake Lacawanna).

f. Downstream Channel. West Fork downstream of Laguna Palma Dam travels approximately 1000 feet before joining Plattin Creek Plattin Creek downstream of the dam has a moderately wide channel.

3.2 EVALUATION. The visual inspection did not reveal any immediate signs of instability. The earth embankment section of the dam appears to be in good condition. The concrete gravity section appears to be in fair condition. Detailed examination of the cracks in the concrete gravity section cannot be made without the reservoir level being dropped. The upstream condition of these cracks if they extend through the dam was unobserved. In addition, with the water discharging over the spillway crest, it was impossible to determine whether any seepage zones exist in the concrete section. Any undercutting of the toe was not determined because of the tailwater.

Complete evaluation of the structure cannot be made without a detailed stability, stress or seepage analysis with tests of concrete or soil, mapping of the cracks and geometry of the concrete and earth embankment section.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES. The reservoir is maintained at the spillway crest. The reservoir has not been drawn down by the present owner.

4.2 MAINTENANCE OF DAM. No maintenance of the dam is conducted.

4.3 MAINTENANCE OF OPERATING FACILITIES. The operating facilities are not maintained.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT. Upon checking with the owner, the inspection team is unaware of any warning system in effect.

4.5 EVALUATION. Maintenance of the dam and operating facilities are considered poor. There is no warning system in effect to warn downstream residences of large spillway discharges of failure of the dam.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. There are no hydrualic and hydrological design data available as discussed in Section 2.

b. Experience Data. The drainage area was developed using the U.S.G.S. quadrangle sheet. The lake surface area was determined by planimetering the quadrangle sheet. Surface area - elevations were determined by planimetering various contour lines within the drainage area on the U.S.G.S. quadrangle sheets. The spillway and dam layout was made from surveys conducted during the inspection. Despite no record of reservoir water levels, there is no evidence or history of the dam being overtopped.

c. Visual Observations. The spillway (60 feet long trapezoid) is located at the right abutment in the concrete gravity section. The right abutment is approximately 10 feet long and 1 foot higher than the spillway crest elevation. This right abutment is formed from concrete and rock and can take overflow. Thus the top of dam is considered 588.7 (left of the spillway). The earth portion of the dam cannot take overtopping for a long period of time. The crest width is narrow and the embankment is formed from sandy clay with gravel. Approximately 2 miles upstream of Laguna Palma Dam is an earth embankment approximately 40 feet high (Lake Lacawanna). The spillway on Lake Lacawanna is approximately 12 feet wide. Failure of Lake Lacawanna may cause overtopping and eventual failure of Laguna Palma Dam. The drainage area is wooded with gentle slopes and the soil condition is considered to be fair regarding hydrologic conditions (hydrologic soil group B).

d. Overtopping Potential. Overtopping potential was investigated through the development of the probable maximum flood (PMF) for the watershed and the subsequent routing of the PMF and fractions of the PMF through the reservoir and spillway.

The Corps of Engineers, St. Louis District, has directed that the HEC-1 Dam Safety Version systemized computer program be utilized. The program was prepared by the Hydraulic Engineering Center (HEC) U.S. Army Corp of Engineers, Davis California, July, 1978. The major methodologies or key input data for this program are discussed in Appendix B.

To enable us to complete the hydraulic and hydrologic analysis for this structure, it was necessary to make the following assumptions:

1. Top of dam was considered 588.7.

2. No flow through the drainline was considered.

3. The flood was routed through the upstream reservoir (Lake Lacawanna).

4. Failure of Lake Lacawanna was not considered.

Complete summary sheets of the computer output are presented in Appendix B. To facilitate review, the major results of the overtopping analysis are presented below:

Peak Inflow	44157 cfs
Spillway Capacity	1413 cfs

Ratio of PMF	Maximum Reservoir Water Surface	Maximum Depth over Dam (embankment)	Maximum Outflow cfs	Duration of over-topping, hours
.10	590.42	1.72	4215	3.33
.50	594.39	5.69	22042	10.50
1.00	597.84	9.14	44364	13.83

The Corps of Engineers Spillway Design Flood for a high hazard-small dam is 1/2 PMF to the PMF. Based on the downstream hazard exposure, the Spillway Design Flood for this dam is the PMF. The spillway is capable of controlling only approximately 3% of the PMF without overtopping the embankment. Overtopping the embankment for an extended period of time or with depth will cause failure of the dam. In addition, the upstream dam (Lake Lacawanna) can control only 2% of the PMF without overtopping the embankment. If Lake Lacawanna should fail due to overtopping an additional 152 acre-feet of water would be suddenly released and probable would cause failure of Laguna Palma.

Because of the low spillway capacity the 10 year storm was routed through the reservoir. The spillway and reservoir can not control the 10 year storm. Despite no record of reservoir water levels there is no evidence or history that the dam has been overtopped.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations did not reveal any signs of immediate instability. The earth embankment portion appeared to be in good condition. The slopes are moderately flat and covered with grasses. No erosion or seepage was noted on the embankment portion during the inspection. The concrete gravity section appeared to be in fair condition. The lake level and discharge through the spillway prevented close observation of the downstream and upstream slopes of the concrete gravity section. However, some deterioration of the concrete was noted. In addition, several long diagonal cracks in the concrete were observed.

b. Design and Construction Data. No design or construction data is available on the dam. The dimensions of the dam cross-section are unknown. No testing of the concrete or earth embankment has been performed. Stability, stress and seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspections of Dams" were not available, which is considered a deficiency.

c. Operating Records. No operating records are kept on the structure.

d. Post Construction Changes. No post-construction changes are known for this structure.

e. Seismic Stability. The dam is located in seismic zone 2, to which the guidelines assign a "moderate" damage potential. No seismic stability analysis has been conducted.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. The visual observations, review of available data, and hydrologic calculations indicate that Laguna Palma Dam's spillway is seriously inadequate. The spillway is capable of controlling approximately 3% of the PMF without overtopping the embankment. In addition, the spillway and reservoir can not control the 10 year storm.

The earth embankment portion of the dam appeared to be in good condition. No erosion or seepage zones were noted in the earth embankment section. The concrete gravity section appears to be in fair condition. Some deterioration of the concrete and several long diagonal cracks were noted on the downstream face. Water discharging over the downstream face may have obscured some features. The high lake level prevented observation of the upstream portions of the concrete gravity section and the earth embankment section. The long term effect of the deterioration and weakening of the concrete is unknown. The concrete in the dam will deteriorate with age and should be analyzed at periodic intervals. Stability, stress and seepage analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspections of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. Complete assessment of the structural stability of the structure cannot be made because of the limited design data and construction data. Stability, stress and seepage analyses comparable to the requirement of the "Recommended Guidelines for Safety Inspections of Dams" were not available, which is considered a deficiency.

c. Urgency. The deficiencies described herein are serious and corrective actions listed below should be initiated immediately. Special note should be made of items listed in paragraph 7.2.a. and these recommendations should be pursued on a high priority basis.

d. Need for Phase II. In order to accomplish some of the recommendations/remedial measures outlined below, further investigations will be required.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

a. Alternatives. A detailed hydraulic and hydrology study should be conducted by a registered professional engineer knowledgeable in dam design to increase the spillway capacity. The study should be gin immediately and remedial modifications begun immediately after the study is complete.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended:

1. Stability, stress and seepage analyses should be conducted of the earth embankment portion of the concrete gravity section by a registered professional engineer knowledgeable in dam design.

2. Concrete samples of the concrete gravity section should be obtained to determine the condition and strength of the concrete.

3. The deteriorated concrete should be repaired.

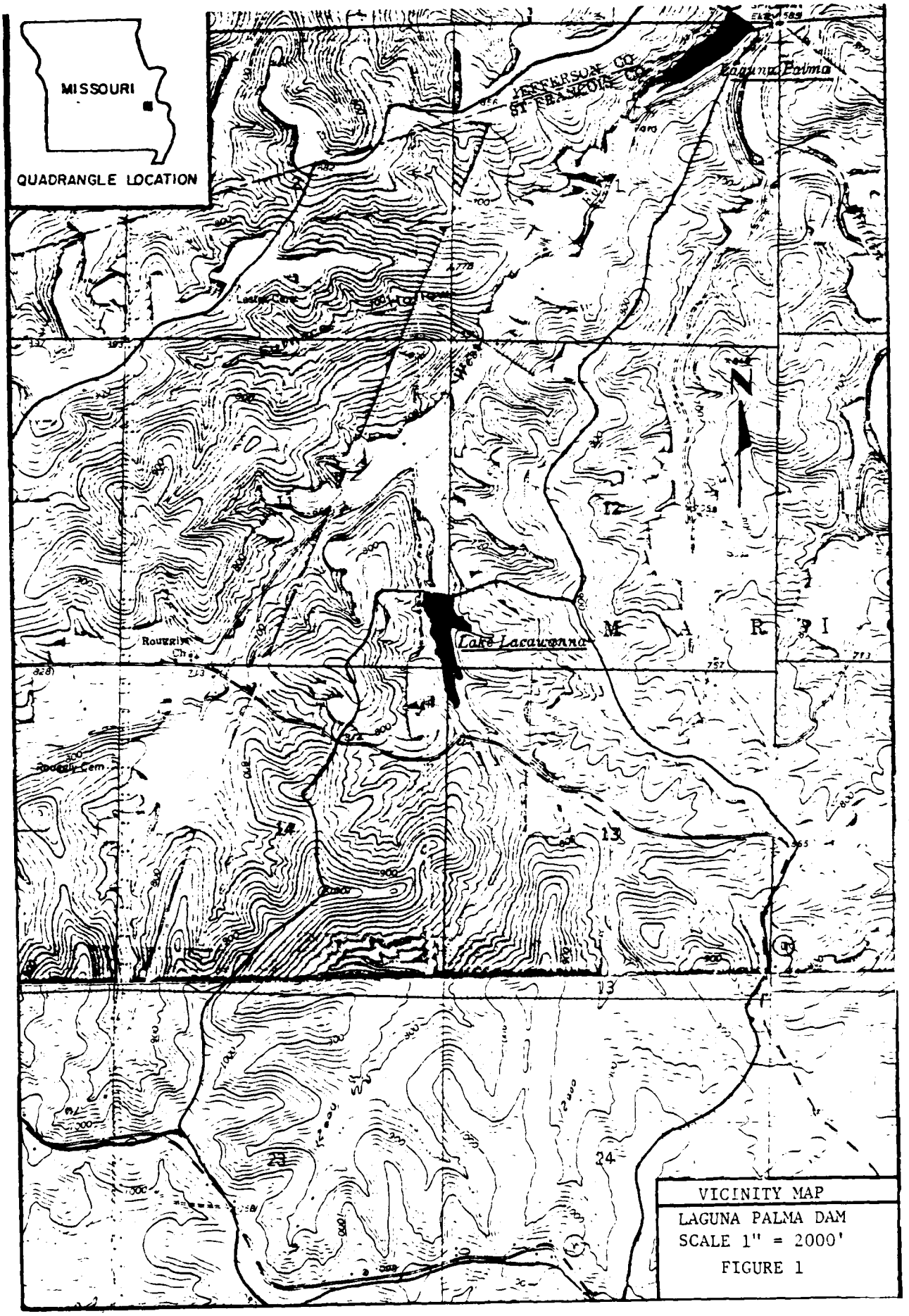
4. Institute a formal inspection program to be conducted at regular intervals.

5. Institute a formal warning system to warn downstream residences of high spillway discharges or failure of the dam.

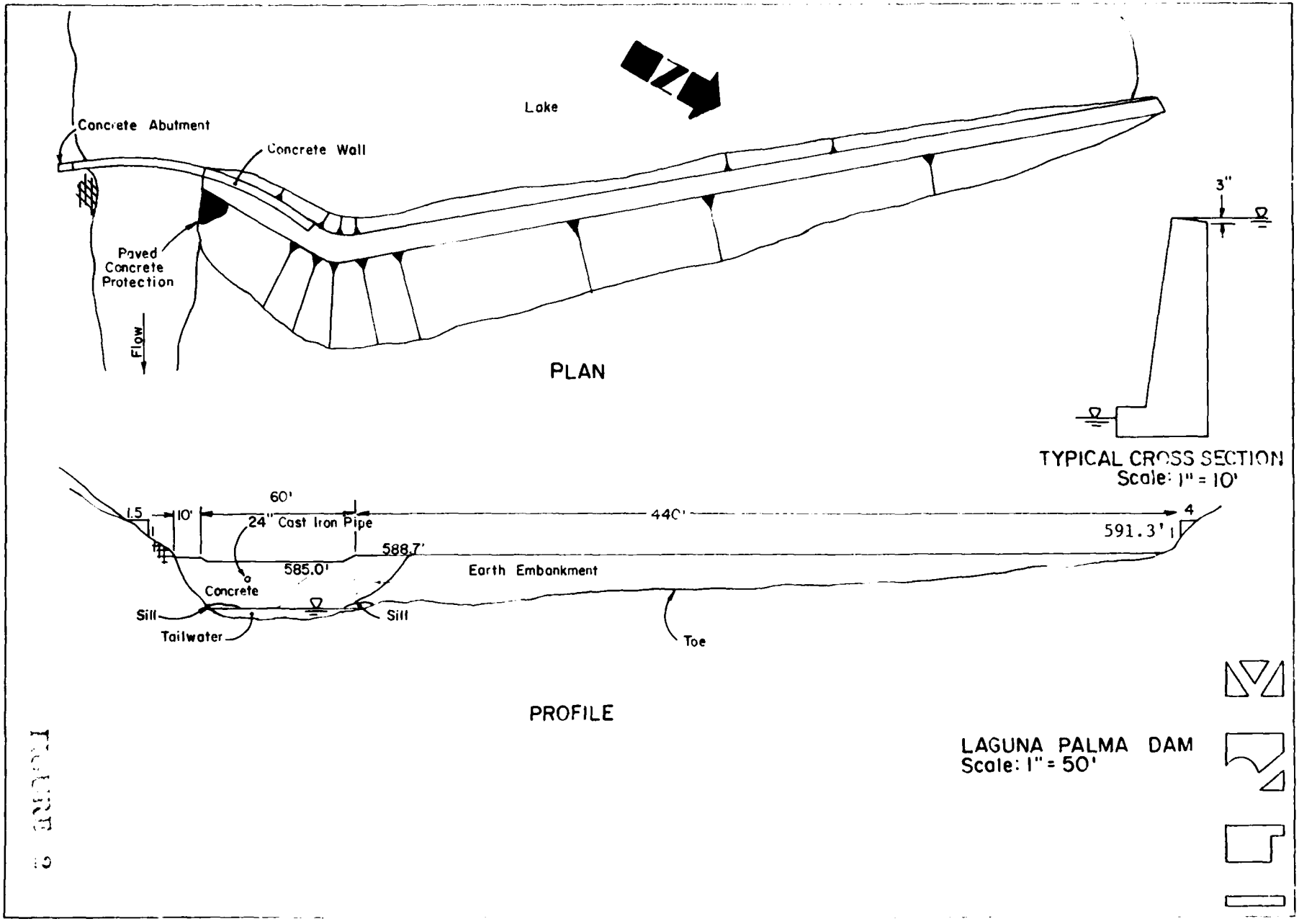
6. The drainline should be made operable. The drainline should be exercised and lubricated at six month intervals.

7. Riprap the upstream slope of the dam.

DRAWINGS



VICINITY MAP
LAGUNA PALMA DAM
SCALE 1" = 2000'
FIGURE 1


Lake
Concrete Abutment
Concrete Wall
Paved Concrete Protection
Flow
PLAN
3"
TYPICAL CROSS SECTION
Scale: 1" = 10'
1.5
1
10'
60'
24" Cast Iron Pipe
440'
4
591.3'
588.7'
585.0'
Earth Embankment
Concrete
Sill
Sill
Tailwater
Toe
PROFILE
LAGUNA PALMA DAM
Scale: 1" = 50'

HYDROLOGY AND HYDRAULICS

APPENDIX B

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

The hydrologic analysis used in development of the overtopping potential is based on applying a hypothetical storm to a unit hydrograph to obtain the inflow hydrograph for a reservoir routing. The Probable Maximum Precipitation is derived and determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33." Reduction factors have not been applied. A 48 hour storm duration is assumed with total depth distributed over 6 hour periods in accordance with procedures outlined in EM 1110-2-1411 (SPF Determination). The maximum 6 hour rainfall period is then distributed to hourly increments by the same criteria. Within-the-hour distribution is based upon NOAA Technical Memorandum NWS HYDRO-35. The non-peak 6 hour rainfall periods are distributed uniformly. All distributed values are arranged in a critical sequence by the SPF criteria. The final inflow hydrograph is produced by deduction of infiltration losses appropriate to the soil, land use, and antecedent moisture conditions.

The reservoir routing is accomplished by using Modified Puls routing techniques wherein the flood hydrograph is routed through lake storage. Hydraulic capacities of the outlet works, spillways, and crest of dam are used as outlet controls in the routing. Storage in the pool area is defined by an elevation-storage capacity curve. The hydraulic capacity of the outlet works, spillways, and top of dam are defined by elevation-discharge curves.

Dam overtopping analysis has been conducted by hydrologic methods for this dam and lake. This computation determines the percentage of the PMF hydrograph that the reservoir can contain without the dam being overtopped. An output summary in the hydrologic appendix displays this information as well as other characteristics of the simulated dam overtopping.

The above analysis has been accomplished for this report using the systemized computer program HEC-1 (Dam Safety Version), July, 1978, prepared by the Hydrologic Engineering Center, U.S. Army Corps of Engineers, Davis, California. The numeric parameters estimated for this site are listed in the computer printout. Definitions of these variables are contained in the "User's Manual" for the computer program.

The inflow hydrograph was routed through the reservoir using HEC-1's Modified Puls option.

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME LAGUNA PALMA DAM
I.D. NUMBER 30404
SHEET NO. 1 OF 4
BY OTM DATE 2-

LAGUNA PALMA DAM

DRAINAGE AREA

AREA = 7.07 SQ. MI (ST. LOUIS D.ST. C.O.E. AND U.S.G.S. 7.5 MIN. QUADS)

UNIT HYDROGRAPH PARAMETERS

KIRPICH METHOD:

t_R = 1.25 HRS (FROM TIME OF CONCENTRATION NOMOGRAPH, KENTUCKY BUREAU OF HIGHWAYS)

$L = 0.6\, t_R$
$= 0.75$ HRS.

WHERE LENGTH = 22,000', HEIGHT = 475'

CURVE NUMBER METHOD:

$$\text{LAG } (L) = \frac{l^{0.8}(S+1)^{0.7}}{1900\, Y^{0.5}} = \frac{(22{,}000)^{0.8}(3.82)^{0.7}}{1900\,(\ 5\ )^{0.5}}$$

$$= \frac{(2978)(2.56)}{4249} = 1.8 \text{ HRS}$$

WHERE l = GREATEST FLOW LENGTH IN FEET
$S = (1000/CN) - 10$ AND Y = AVERAGE SLOPE

LOSS RATE AND BASE FLOW

STRTL	=	1.0	INCH
CNSTL	=	78.0	SCS CURVE NUMBER (C.N)
STRTQ	=	1.5	CFS/MI^2
QRCSN	=	0.05	(5% OF PEAK FLOW)
RTIOR	=	2.5	

UTILIZED ANTECEDENT MOISTURE CONDITION III (SOIL GROUP B)

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME LAGUNA PALMA DAM
I.D. NUMBER 304C+
SHEET NO. 2 OF 4
BY OTM DATE 3-

PROBABLE MAXIMUM STORM

FROM H.R. NO. 33

P.M.P. INDEX RAINFALL (ZONE 7) = 26.0 INCHES
R_6 = 102 %, R_{12} = 120 %, R_{24} = 130 %, R_{48} = 140 %

ELEVATION-AREA-CAPACITY RELATIONSHIP

SPILLWAY CREST ELEV. = 595', AREA = 16 ACRES
INITIAL STORAGE = 98 AC-FT
(FROM FIELD INSPECTION DATA, ST. LOUIS DIST. C.O.E. INFO, AND U.S.G.S. 7.5-MN. QUADS)

ELEV. 600', AREA = 41 AC.
ELEV. 620', AREA = 83 AC.

FROM CONIC METHOD FOR RESERVOIR VOLUME, FLOOD HYDROGRAPH PACKAGE (HEC-1), DAM SAFETY VERSION (USERS MANUAL).

$H = 3V/A = 3(98\ AC\cdot FT)/16\ AC. \approx 18'$

∴ ELEV. WHERE CAPACITY EQUALS ZERO; 585' - 18' = 567'

ELEVATION (FT.)	567	585	588	592	596	598	600
AREA (AC.)	0	16	20	26	32	36	41

OVERTOPPING PARAMETERS

DISCHARGE DETERMINED BY HEC-1.

TOP OF DAM (LOW SPOT) = 588.7', C = 3.0 (BROAD CREST)
LENGTH OF DAM (EXCLUDING SPILLWAY) = 440'

L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME LAGUNA PALMA DAM
I.D. NUMBER 30404
SHEET NO. 3 OF 4
BY OTM DATE 3-[illegible]

SPILLWAY RATING CURVE

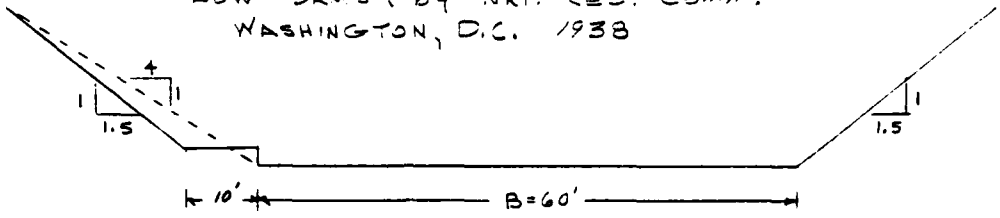
FROM EQUATION FOR TRAPEZOIDAL SPILLWAY FLOW.

$$Q = 8.03\, C' h_v^{1/2} (h_p - h_v) [B + Z(h_p - h_v)]$$

WHERE $h_v = \dfrac{3(2Zh_p + B) - (16Z^2 h_p^2 + 16ZBh_p + 9B^2)^{1/2}}{10Z}$

AND $C' = 0.95$, $B = 60'$ & $Z = 2.75$

LOW DAMS, by NAT. RES. COMM. WASHINGTON, D.C. 1938



NOT TO SCALE

ELEVATION (FT.)	h_p (FT.)	*DISCHARGE Q (CFS)
585	0	0
585.5	.5	60
586	1	180
586.5	1.5	340
587	2	530
587.5	2.5	750
588	3	1000
588.5	3.5	1280
589	4	1590
590	5	2280
591	6	3080
592	7	3980
593	8	4990
594	9	6110
595	10	7330

* VALUES ROUNDED TO NEAREST 10 CFS

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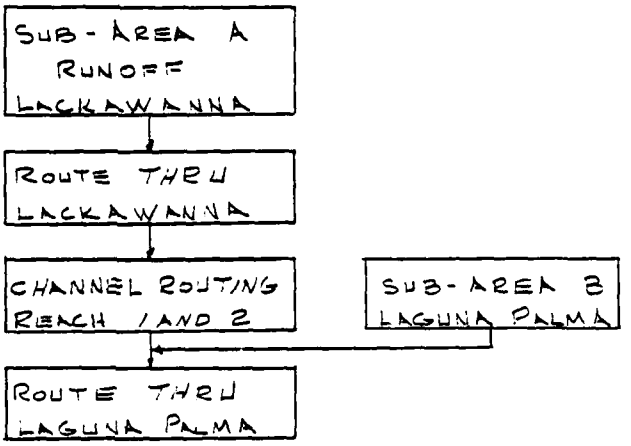
CONSULTING ENGINEERS & ARCHITECTS
EBENSBURG PENNSYLVANIA

DAM NAME LAGUNA PALMA DAM
I.D. NUMBER 30494
SHEET NO. 1 OF 4
BY DTM DATE 3-4-93

NETWORK SCHEMATIC



STREAM ROUTING

ROUTING CROSS-SECTIONS OBTAINED FROM U.S.G.S. 7.5-MIN. QUADS.

CHANNEL MANNING'S (n), $Q_N(1) = 0.06$, $Q_N(2) = 0.05$

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
 LAST MODIFICATION  26 FEB 79
**********
    1          A1       ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
    2          A2       HYROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF LAGUNA PALMA DAM
    3          A3       RATIOS OF PMF ROUTED THROUGH THE RESERVOIR  (MISSOURI = 30404)
    4          B   288       0      10       0       0       0       0       0      -4       0
    5          B1    5
    6          J     1       3       1
    7          J1   .1      .5       1
    8          K     0       1                                       1
    9          K1       RUNOFF SUB-AREA A (LACKAWANNA)
   10          M     1       2     2.3               7.07       1                       1
   11          P            26.0     102     120     130     140
   12          T                                                   -1     -78
   13          W2           .4
   14          X  -1.5    -.05     2.5
   15          K     1       2                                       1
   16          K1       ROUTE THRU LACKAWANNA
   17          Y                                1       1
   18          Y1    1                                           -682      -1
   19          Y4  682     683     684     685     686     688     690     692     695     700
   20          Y5    0      40     110     230     380     790    1380    2150    3690    7890
   21          SA    0      14      29    73.5
   22          SE 662.7     682     700     720
   23          SS  682
   24          SD  686     3.0     1.5     500
   25          K     1       3                                       1
   26          K1       CHANNEL ROUTING - MOD PULS REACH 1
   27          Y                                1       1
   28          Y1    1
   29          Y6  .06     .05     .06     618     660    4000   .0100
   30          Y7    0     660      80     640     150     620     180     618     190     618
   31          Y7  220     620     475     640     550     660
   32          K     1       4                                       1
```

```
KI       CHANNEL ROUTING - MOD PULS REACH 2
Y                                      1       1
Y1       1
Y6     .06     .05     .06     583     660    4000   .0088
Y7       0     660      80     640     150     620     180     618     190     618
Y7     220     620     475     640     550     660
K        0       5                                       1
K1       RUNOFF SUB-AREA B (LAGUNA PALMA)
M        1       2    4.77            7.07       1                       1
P             26.0     102     120     130     140
T                                                       -1     -78
W2             .75
X     -1.5    -.05     2.5
K        2       7                               4       1
K1       COMBINE
K        1       6                                       1
K1       ROUTE THRU LAGUNA PALMA
Y                                      1       1
Y1       1                                            -585      -1
Y4     585     586     587     588     589     590     591     592     593     595
Y5       0     100     330    1000    1590    2280    3060    3980    4990    7330
SA       0      16      20      26      32      36      41
SE   566.6     585     588     592     596     598     600
SS     585
SQ   588.7     3.0     1.5     440
SL      75     105     430     440
SV   588.7     589     590     591
K       99
```

```
**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********************************

RUN  DATE  79/08/08.
     TIME  15.59.51.
```

ANALYSIS OF DAM OVERTOPPING USING RATIOS OF PMF
HYROLOGIC-HYDRAULIC ANALYSIS OF SAFETY OF LAGUNA PALMA DAM
RATIOS OF PMF ROUTED THROUGH THE RESERVOIR (MISSOURI = 304041

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	10	0	0	0	0	0	-4	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 3 LRTIO= 1

RTIOS= .10 .50 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

RUNOFF SUB-AREA A (LACKAWANNA)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	2.30	0.00	7.07	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	26.00	102.00	120.00	130.00	140.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-78.00	0.00	0.00

CURVE NO = -78.00 WETNESS = -1.00 EFFECT CN = 78.00

UNIT HYDROGRAPH DATA

TC= 0.00 LAG= .40

RECESSION DATA

STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.50

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	26.50	23.22	3.18	2959746.
										1.02	.84	.12	8381.05

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE THRU LACKAWANNA

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-682.	-1

STAGE	682.00	683.00	684.00	685.00	686.00	688.00	690.00	692.00	695.00
700.00									
FLOW	0.00	40.00	110.00	230.00	380.00	790.00	1380.00	2150.00	3690.00
7390.00									
SURFACE AREA=	0.	14.	29.	74.					
CAPACITY=	0.	90.	469.	1460.					
ELEVATION=	682.	682.	700.	720.					

CREL	SPWID	COQW	EXPW	ELEVL	COOL	CAREA	EXPL
682.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
686.0	3.0	1.5	500.

PEAK OUTFLOW IS 1705. AT TIME 40.17 HOURS

PEAK OUTFLOW IS 8950. AT TIME 40.00 HOURS

PEAK OUTFLOW IS 18064. AT TIME 40.00 HOURS

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

CHANNEL ROUTING - MOD PULS REACH 1

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
3	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0600	.0500	.0600	618.0	660.0	4000.	.01000

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 660.00 80.00 640.00 150.00 620.00 180.00 618.00 190.00 618.00
220.00 620.00 475.00 640.00 550.00 660.00

STORAGE	0.00	8.73	27.28	53.12	86.23	126.68	174.39	229.40	291.70
361.29									
	438.17	520.25	605.81	694.85	787.37	883.36	982.83	1085.78	1192.21
1302.11									
OUTFLOW	0.00	345.18	1865.75	4624.29	8775.10	14479.30	21895.19	31176.39	42471.68
55925.29									

	71745.17	91287.97	113162.29	137362.58	163893.95	192769.06	224006.06	257627.24	293658.05
332126.37									
STAGE	618.00	620.21	622.42	624.63	626.84	629.05	631.26	633.47	635.68
637.89									
	640.11	642.32	644.53	646.74	648.95	651.16	653.37	655.58	657.79
660.00									
FLOW	0.00	345.18	1865.75	4624.29	8775.10	14479.30	21895.19	31176.39	42471.68
55925.29									
	71745.17	91287.97	113162.29	137362.58	163893.95	192769.06	224006.06	257627.24	293658.05
332126.37									

MAXIMUM STAGE IS 622.0

MAXIMUM STAGE IS 626.8

MAXIMUM STAGE IS 629.9

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

CHANNEL ROUTING - MOD PULS REACH 2

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
4	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0600	.0500	.0600	583.0	660.0	4000.	.00880

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00 660.00 80.00 640.00 150.00 620.00 180.00 618.00 190.00 618.00
220.00 620.00 475.00 640.00 550.00 660.00

STORAGE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.34	39.29	98.92	183.06	291.70	424.85	576.90	740.67	916.13	1103.28
1302.11									
OUTFLOW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
120.65	2890.25	9846.12	21865.26	39841.97	64621.24	99073.21	141027.89	190353.89	247151.44
311562.15									
STAGE	583.00	587.05	591.11	595.16	599.21	603.26	607.32	611.37	615.42
619.47	623.53	627.58	631.63	635.68	639.74	643.79	647.84	651.89	655.95
660.00									
FLOW	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
120.65	2890.25	9846.12	21865.26	39841.97	64621.24	99073.21	141027.89	190353.89	247151.44
311562.15									

MAXIMUM STAGE IS 621.5

MAXIMUM STAGE IS 626.6

MAXIMUM STAGE IS 629.9

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

RUNOFF SUB-AREA B (LAGUNA PALMA)

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
5	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	4.77	0.00	7.07	1.00	0.000	0	1	0

PRECIP DATA

SPFE	PMS	R6	R12	R24	R48	R72	R96
0.00	26.00	102.00	120.00	130.00	140.00	0.00	0.00

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-78.00	0.00	0.00

CURVE NO = -78.00 WETNESS = -1.00 EFFECT CN = 78.00

UNIT HYDROGRAPH DATA

TC= 0.00 LAG= .75

RECESSION DATA

STRTQ= -1.50 QRCSN= -.05 RTIOR= 2.50

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	36.40	33.22	3.18	609191.

(925.)(844.)(81.)(17250.37)

********** ********** ********** ********** **********

COMBINE HYDROGRAPHS

COMBINE

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
7	2	0	0	0	4	1	0	0

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE THRU LAGUNA PALMA

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
6	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	-585.	-1

STAGE	585.00	586.00	587.00	588.00	589.00	590.00	591.00	592.00	593.00
FLOW	0.00	180.00	530.00	1000.00	1590.00	2280.00	3080.00	3980.00	4990.00
7330.00									
SURFACE AREA=	0.	16.	20.	26.	32.	36.	41.		

CAPACITY=	0.	98.	152.	244.	350.	428.	504.
ELEVATION=	567.	585.	588.	592.	596.	598.	600.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
585.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
588.7	3.0	1.5	440.

CREST LENGTH AT OR BELOW ELEVATION	75.	109.	430.	440.
	588.7	589.0	590.0	591.0

PEAK OUTFLOW IS 4215. AT TIME 40.50 HOURS

PEAK OUTFLOW IS 22048. AT TIME 40.33 HOURS

PEAK OUTFLOW IS 44364. AT TIME 40.33 HOURS

********** ********** ********** ********** **********

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .10	RATIO 2 .50	RATIO 3 1.00
HYDROGRAPH AT	1	2.30 (5.96)	1	1824. (51.64)	9118. (258.19)	18236. (516.39)
ROUTED TO	2	2.30 (5.96)	1	1705. (48.27)	8950. (253.45)	18064. (511.52)
ROUTED TO	3	2.30 (5.96)	1	1595. (45.16)	8635. (244.51)	17458. (494.35)
ROUTED TO	4	2.30 (5.96)	1	1508. (42.70)	8126. (230.10)	16870. (477.69)
HYDROGRAPH AT	5	4.77 (12.35)	1	2799. (79.26)	13995. (396.29)	27989. (792.57)
2 COMBINED	7	7.07 (18.31)	1	4307. (121.96)	22121. (626.39)	44157. (1250.39)
ROUTED TO	8	7.07 (18.31)	1	4219. (119.35)	22042. (624.16)	44364. (1256.24)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ..... INITIAL VALUE | SPILLWAY CREST | TOP OF DAM

ELEVATION	682.00	682.00	686.00
STORAGE	90.	90.	152.
OUTFLOW	0.	0.	380.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	686.84	.84	166.	1705.	3.67	40.17	0.00
.50	689.02	3.02	206.	8950.	11.00	40.00	0.00
1.00	690.91	4.91	244.	18064.	17.17	40.00	0.00

PLAN 1 STATION 3

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	1595.	622.0	40.17
.50	8635.	626.8	40.17
1.00	17458.	629.9	40.17

PLAN 1 STATION 4

RATIO	MAXIMUM FLOW,CFS	MAXIMUM STAGE,FT	TIME HOURS
.10	1508.	621.9	40.33
.50	8126.	626.6	40.33
1.00	16870.	629.9	40.17

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ..... INITIAL VALUE SPILLWAY CREST TOP OF DAM

ELEVATION	585.00	585.00	588.70
STORAGE	98.	98.	166.
OUTFLOW	0.	0.	1413.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	590.42	1.72	205.	4215.	3.33	40.50	0.00
.50	594.39	5.69	310.	22042.	10.50	40.33	0.00
1.00	597.84	9.14	422.	44364.	13.83	40.33	0.00

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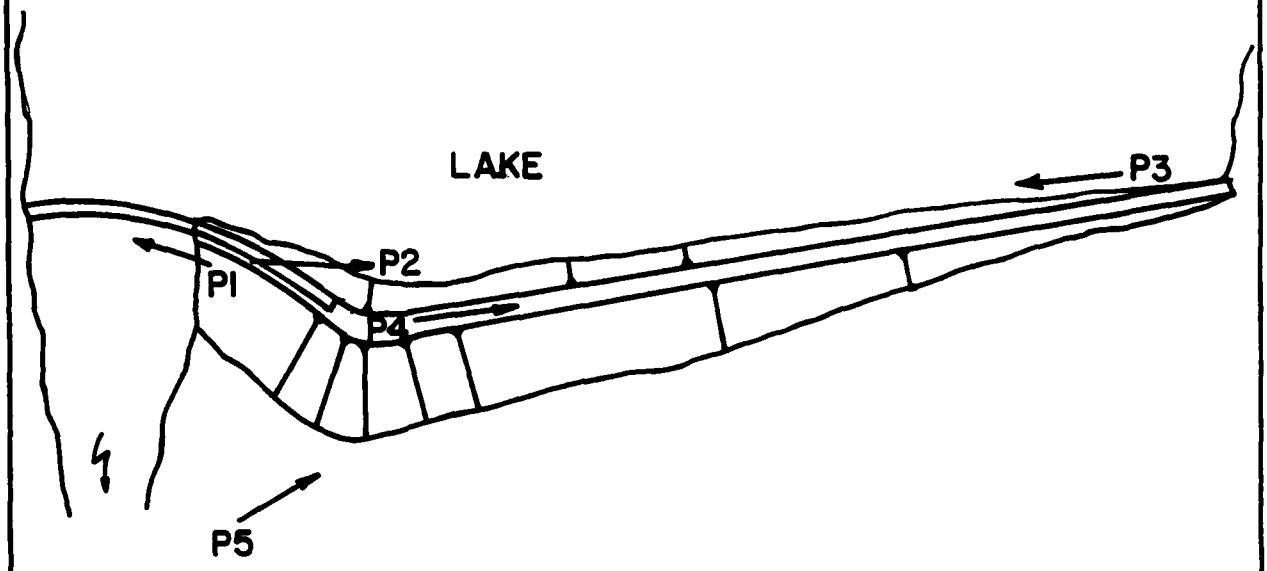
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79
****

PHOTOGRAPHS

Photos 6 and 7 Upstream Dam
(Lake Lacawanna)



P-INDICATES PHOTO LOCATION

LAGUNA PALMA DAM
PHOTO INDEX

Photograph No. 1

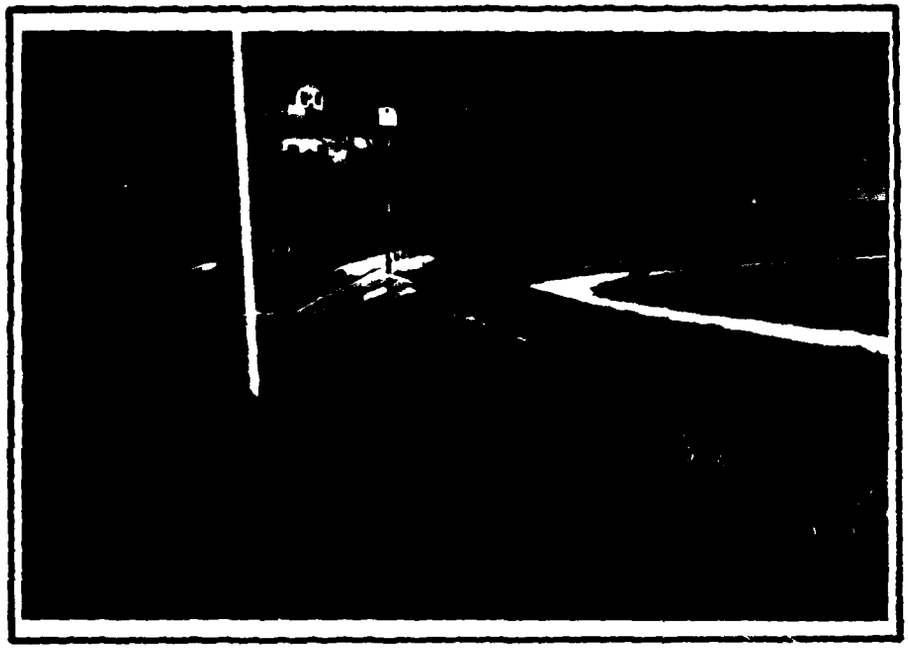
Spillway.

Photograph No. 2

Upstream slope of earth embankment section.
Note concrete wall in foreground.

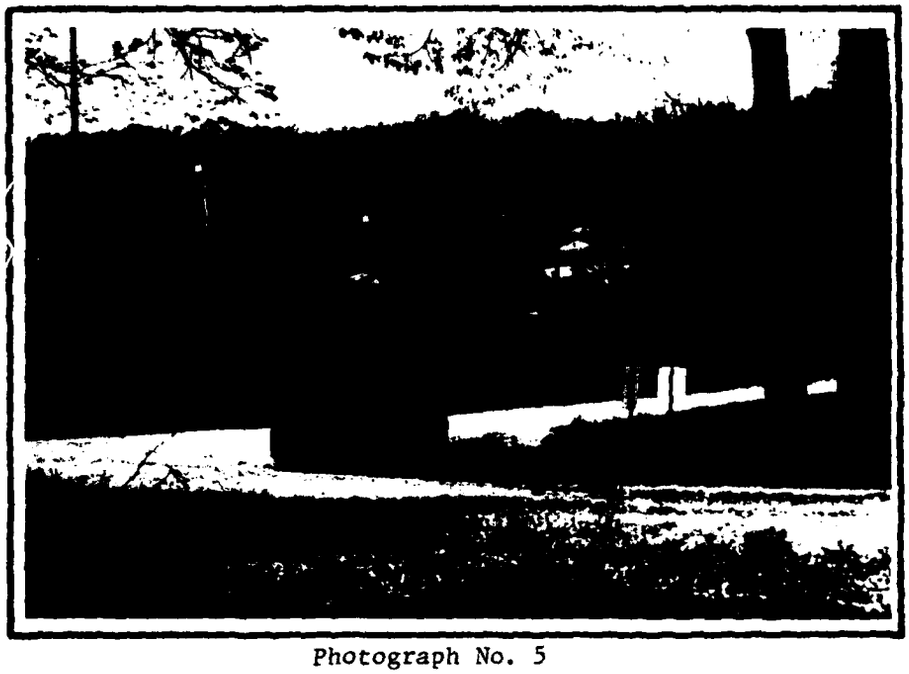
Photograph No. 3

Upstream slope of earth embankment section.



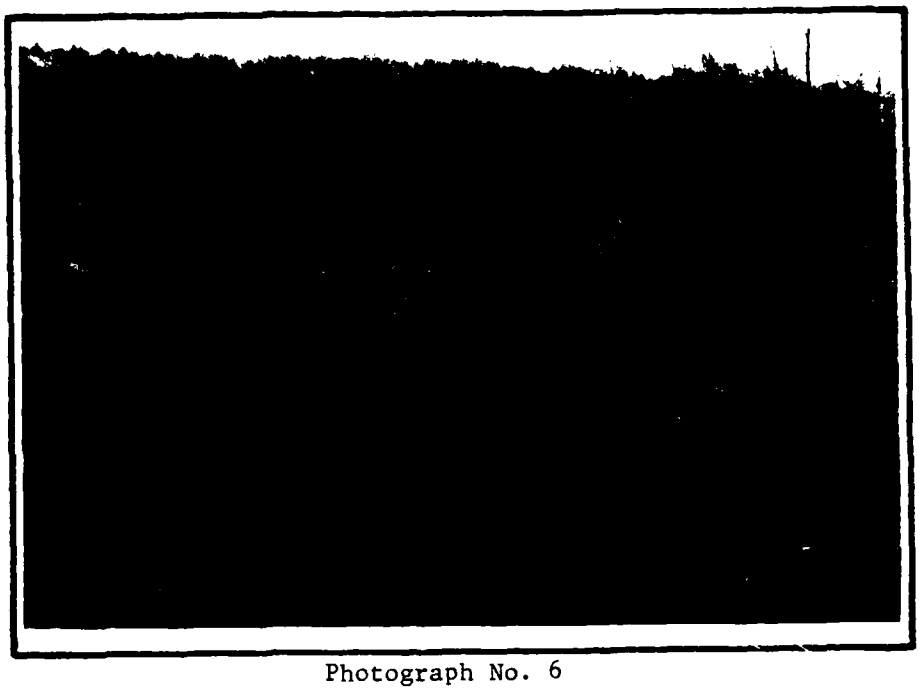
Photograph No. 4

Earth embankment.



Photograph No. 5

Downstream slope of earth embankment.



Photograph No. 6

Lake Lacawanna.

Photograph No. 7

Lake Lacawanna spillway.